International MODIS/AIRS Processing Package (IMAPP) Products and Applications
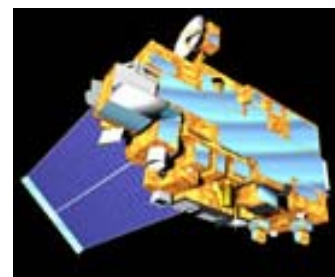
Allen Huang, Liam Gumley, **Kathleen Strabala**, Tom Rink, Jim Davies, Jun Li, Kevin Baggett, Jun Huang, Guan Li

Cooperative Institute for Meteorological Satellite Studies

University of Wisconsin - Madison

International MODIS/AIRS Processing Package (IMAPP)

Builds upon our previous experience with
• ITPP (International TOVS Processing Package) since 1983
• IAPP (International ATOVS Processing Package) since 1998

Purpose:
• The intention in developing IMAPP for processing direct broadcast MODIS and AIRS data is to help foster the rapid improvement of retrieval algorithms and other applications of EOS data in a variety of global weather, process studies, and climate applications, just as the ITPP and IAPP have done for TOVS and ATOVS data.

Available from:
http://cimss.ssec.wisc.edu/~gumley/IMAPP/

International MODIS/AIRS Processing Package

Goal: Transform direct broadcast Level-0 data to calibrated & geolocated radiances (Level-1B) and science data products (Level-2).

Features:
• Ported to a range of platforms (IRIX, SunOS, AIX, HPUX, Linux),
• The only required tool kit is NCSA HDF4,
• Processing environment is greatly simplified,
• Passes of arbitrary size may be processed,
• Available at no cost; licensed under GNU GPL
• Funded by NASA (250K/yr 01-03, 350K/yr 03-06)

Available from:
   http://cimss.ssec.wisc.edu/~gumley/IMAPP/

Terra

Launched: Dec. 18, 1999
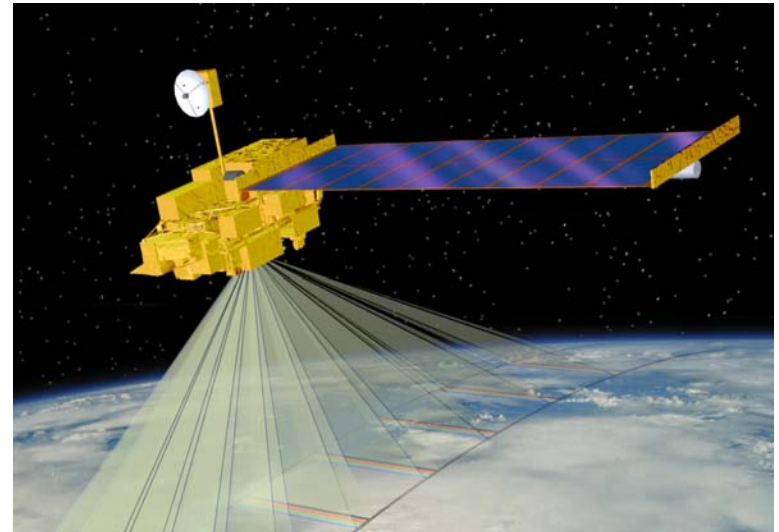
10:30 am ascending

ASTER: Hi-res imager

CERES: Broadband scanner

MISR: Multi-view imager

MODIS: Multispectral imager

MOPITT: Limb sounder

Aqua

Launched: May 4, 2002
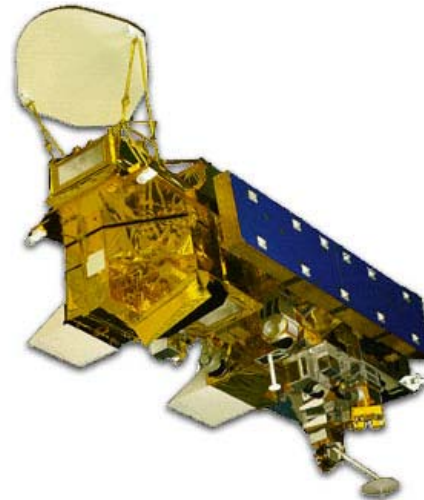
1:30 pm descending

AIRS: Infrared sounder

AMSR-E: Microwave scanner

AMSU: Microwave scanner

CERES: Broadband scanner

HSB: Microwave sounder

MODIS: Multispectral imager

Instruments On Board Aqua

AIRS- Atmospheric Infrared Sounder

Measurements:

Atmospheric temperature and humidity; land and sea surface temperatures; cloud properties; radiative energy flux
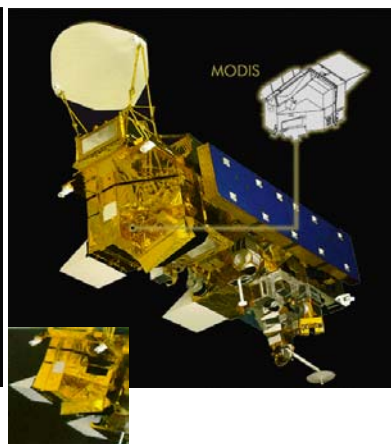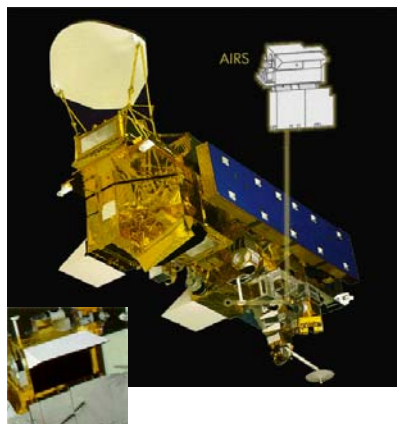
Properties:

Measures simultaneously in more than 2,300 spectral channels in the range of 0.4 to 1.7 µm and 3.4 to 15.4 µm

Sponsor: NASA JPL

Developer: Lockheed Martin

URL: http://www-airs.jpl.nasa.gov/

MODIS-Moderate Resolution Imaging Spectroradiometer

Measurements:

Cloud properties; radiative energy flux; aerosol properties; land cover and land use change; vegetation dynamics; land surface temperature; fire occurrence; volcanic effects; sea surface temperature; ocean color; snow cover; atmospheric temperature and humidity; sea ice
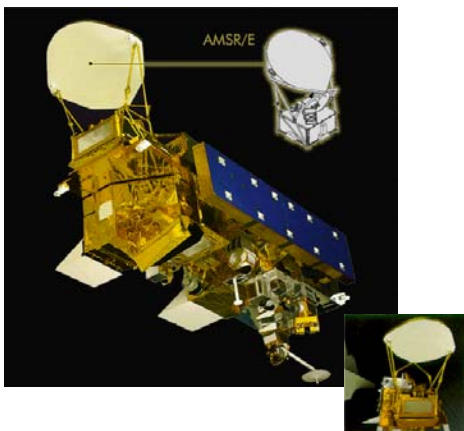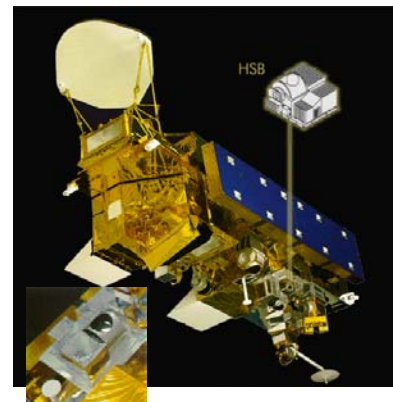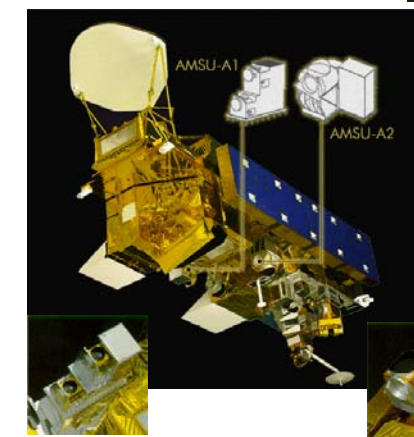
Properties:

Views in 36 spectral bands from 0.4 to 14 µm

Sponsor: NASA GSFC

Developer: Raytheon (Santa Barbara Remote Sensing)

URL: http://ltpwww.gsfc.nasa.gov/MODIS

AMSR/E- Advanced Microwave Scanning Radiometer-EOS

Measurements:

Cloud properties; radiative energy flux; precipitation; land surface wetness;sea ice; snow cover; sea surface temp.; sea surface wind fields

Properties:

Views in 12 channels at six discrete frequencies in the range of 6.9 to 89 GHz

Sponsor: NASDA of Japan

Developer: Mitsubishi Electric Corporation

URL:http://wwwghcc.msfc.nasa.gov/AMSR

AMSU-Advanced Microwave Sounding Unit

Measurements: Atmospheric temperature and humidity

Properties: Senses in 15 discrete channels in the range of 50 to 89 GHz

Sponsor: NASA GSFC   Developer:Aerojet

URL: http://www.aerojet.com/Weapon_Systems/Earth_Sensing/AMSU/

New AMSU info URL: http://orbit-net.nesdis.noaa.gov/crad/st/amsuclimat

HSB- Humidity Sounder for Brazil

Measurements: Atmospheric humidity

Properties: Measures in 5 discrete channels in the range of 150 to 183MHz

Sponsor: Instituto Nacional de Pesquisas Espaciais (INPE), Brazil

Developer:Matra Marconi Space

CERES- Clouds and the Earth's Radiant Energy System

Measurements:Radiative energy flux

Properties: Two sensor, one scanning cross track, the other scanning azimuthally view in three channels per scanner: shortwave (0.3 to 5 µm), longwave (8 to 12 µm), and "total" (0.3 to > 50 µm)

Sponsor: NASA LaRC

Developer: TRW Space & Electronics Group

URL: http://asd-www.larc.nasa.gov/ceres/ASDceres.html

Current IMAPP Status

MODIS products

- calibration, geolocation (L1B)
- cloud mask
- cloud properties (height, temperature, emissivity, phase)
- atmospheric profiles (T, q, tpw, total ozone, stability indices)
- sea surface temperatures
- aerosol optical depth

MODIS utilities

- destriping band 26 (correct for band 5 spectral leak)
- Creating true color images tutorial

AIRS products

- AIRS/AMSU/HSB Level 1 (with JPL)
- AIRS Level 2 profiles in testing (both single pixel and 3x3)

AMSR-E products

- RSS L1B software has been successfully tested – released soon

Local Applications

EOS Direct Broadcast Groundstation

TeraScan SX-EOS 4.4 m antenna: First data acquired 2000/08/18

Overpass prediction 2000/10/13

http://eosdb.ssec.wisc.edu/modisdirect/

CIMSS Near-Real Time IMAPP automated processing
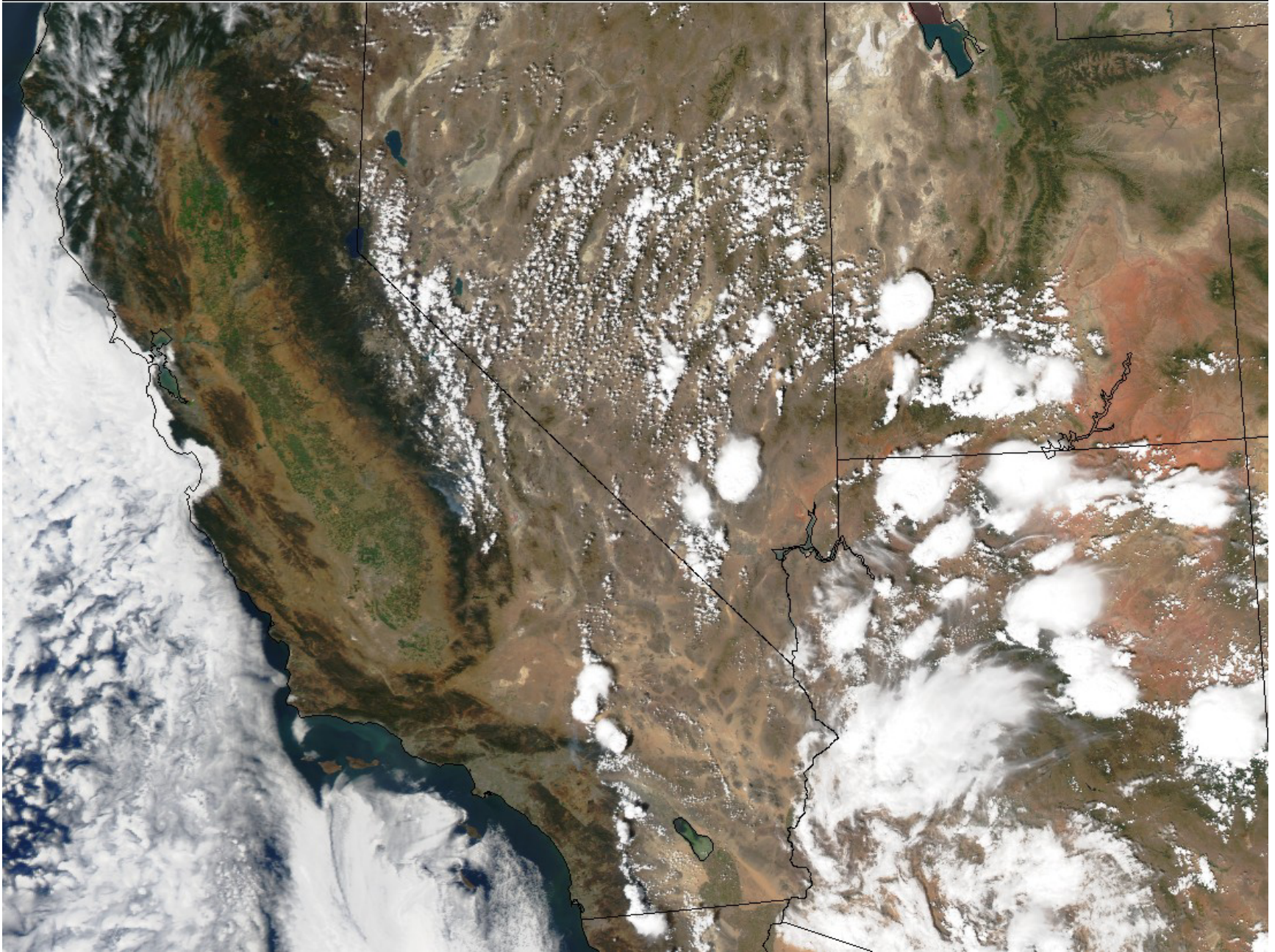
Applications:

- MODIS L1B and science product validation

- Testing of MODIS operational product changes

- Quick look images for identifying regions of spectral or meteorological interest

- Support for field experiments

- Public Service

- Channel simulation for future instruments (Advanced Baseline Imager - 2012)

http://cimss.ssec.wisc.edu/goes/abi/airs_broadcast/aniairs.html

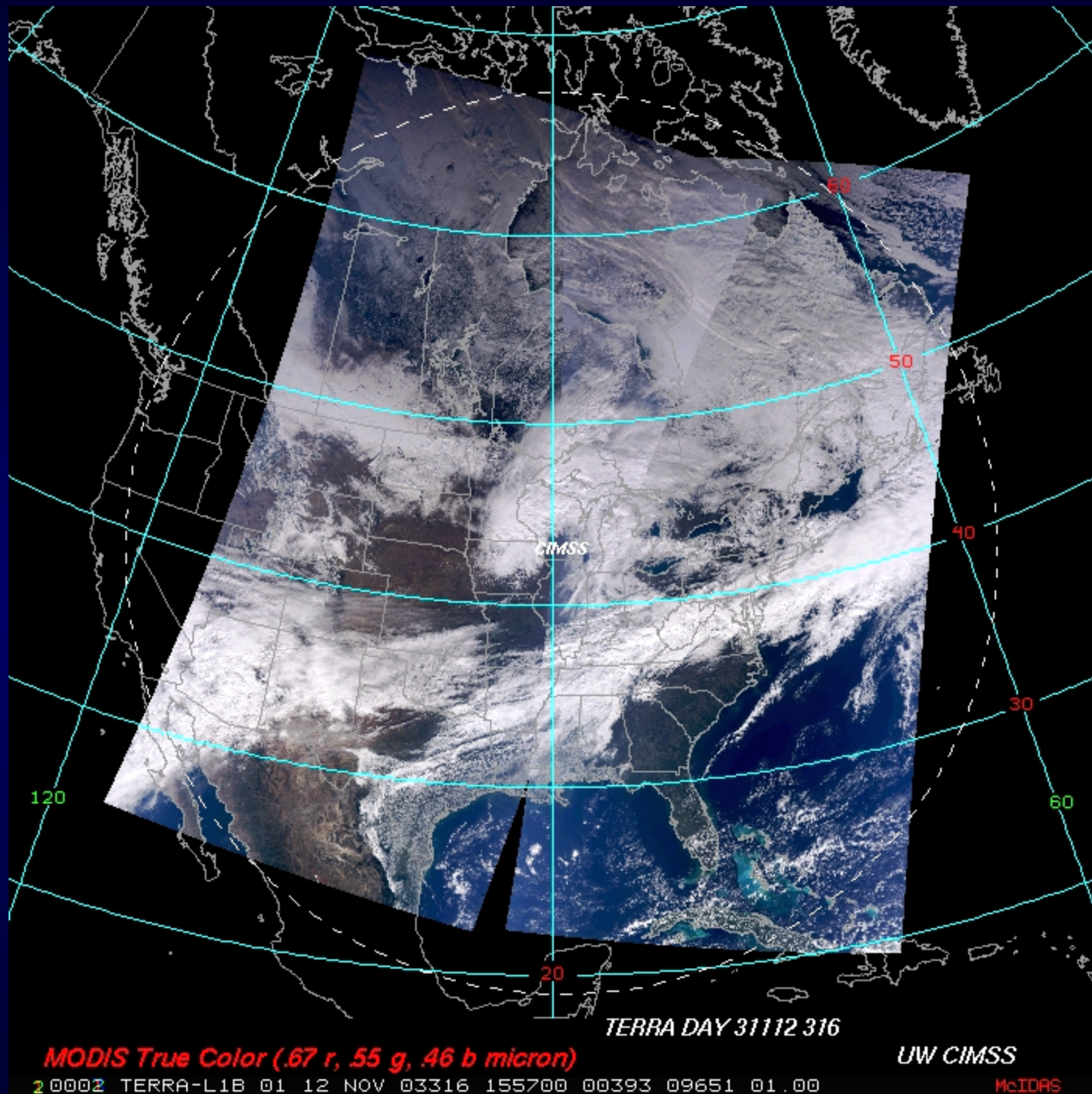# Example IMAPP Aqua Quicklook Image: Southwest US 19 Aug. 2003

AQUA MODIS 2003-08-19 2035-2040 UTC Bands 010403: Southwest US   SSEC UW-MADISON DIRECT BROADCAST
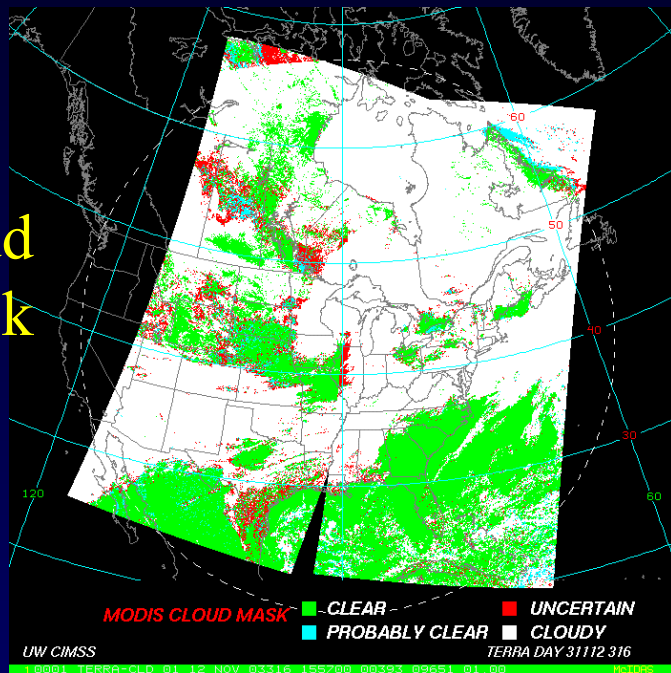
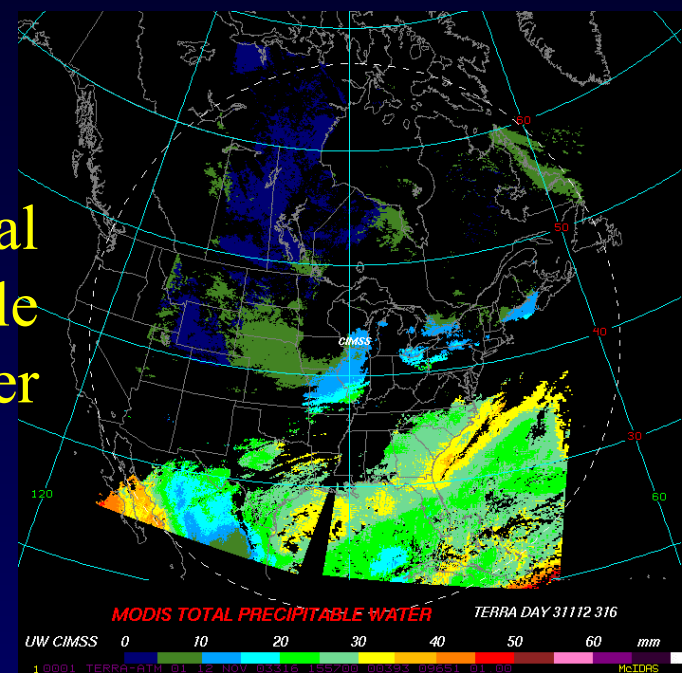IMAPP
Terra/Aqua
MODIS
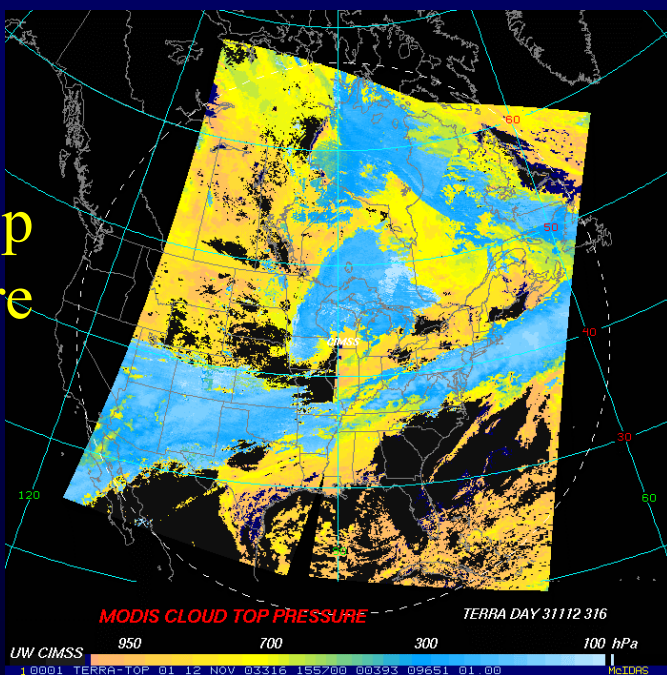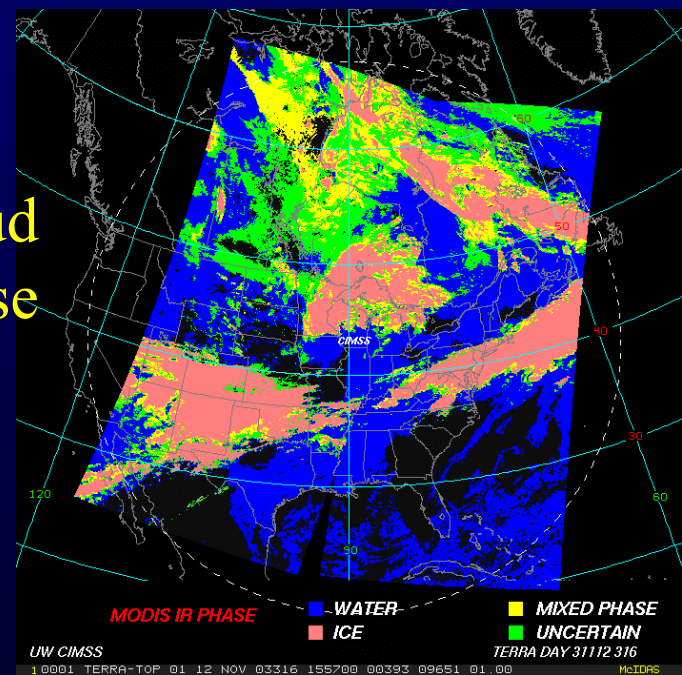Level 2
Products

Automatic
Production at
SSEC

CIMSS

TERRA DAY 31112 316

MODIS True Color (.67 r, .55 g, .46 b micron)

UW CIMSS

2 00002 TERRA-L1B 01 12 NOV 03316 155700 00393 09651 01.00

McIDAS

Cloud Mask

MODIS CLOUD MASK — CLEAR — UNCERTAIN — PROBABLY CLEAR — CLOUDY
UW CIMSS — TERRA DAY 31112 316
10001 TERRA-CLD 01 12 NOV 03316 155700 00393 09651 01.00 — McIDAS

Total Precipitable Water

MODIS TOTAL PRECIPITABLE WATER — TERRA DAY 31112 316
UW CIMSS — 0 — 10 — 20 — 30 — 40 — 50 — 60 — mm
10001 TERRA-ATM 01 12 NOV 03316 155700 00393 09651 01.00 — McIDAS

Cloud Top Pressure

MODIS CLOUD TOP PRESSURE — TERRA DAY 31112 316
UW CIMSS — 950 — 700 — 300 — 100 hPa
10001 TERRA-TOP 01 12 NOV 03316 155700 00393 09651 01.00 — McIDAS

Cloud Phase

MODIS IR PHASE — WATER — MIXED PHASE — ICE — UNCERTAIN
UW CIMSS — TERRA DAY 31112 316
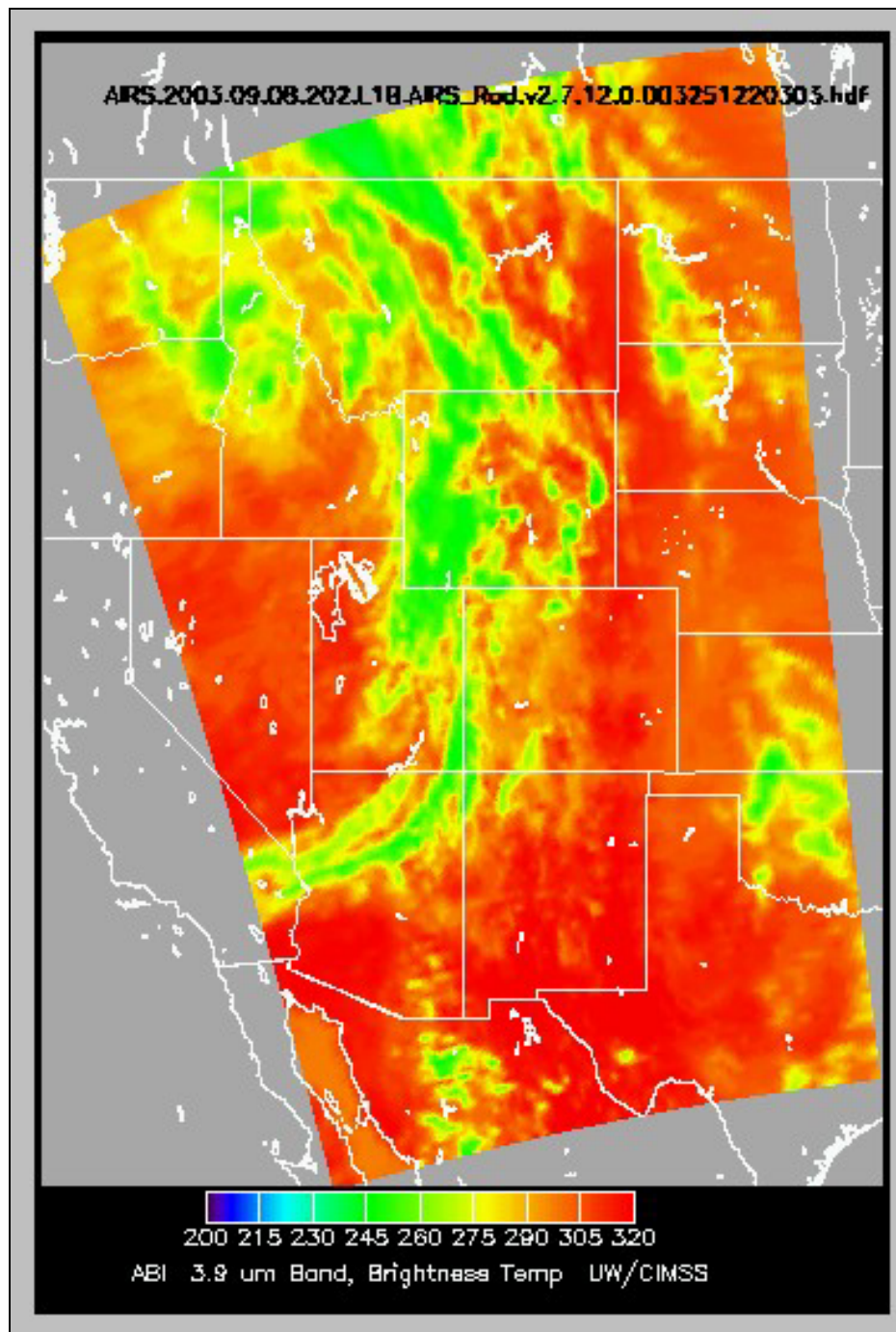10001 TERRA-TOP 01 12 NOV 03316 155700 00393 09651 01.00 — McIDAS

IMAPP MODIS Aerosol Retrieval
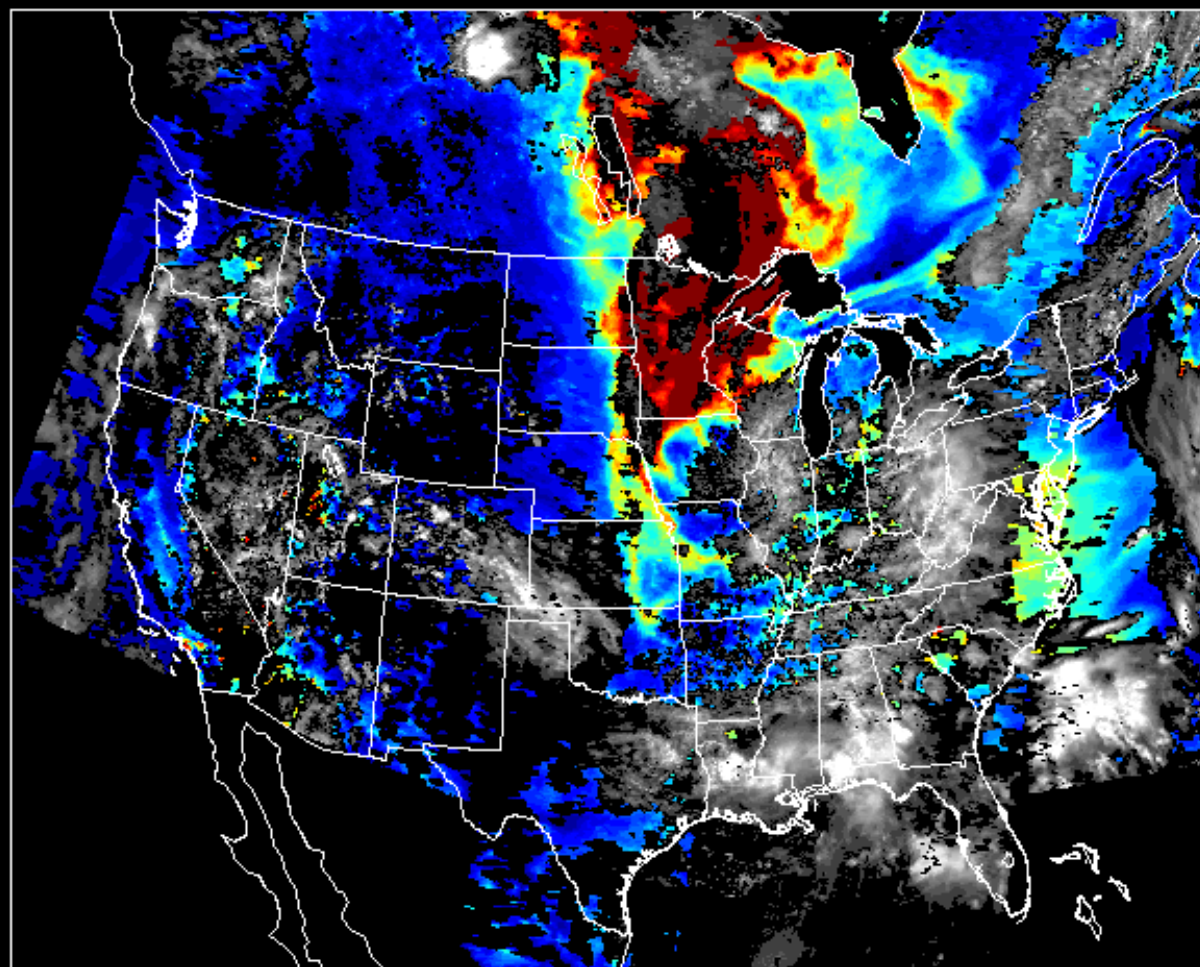
Northern Wisconsin   7 October 2003

Northern Wisconsin   10 October 2003

Simulated Advanced Baseline Imager (ABI) 3.9 micron Brightness Temperature from AIRS UW Direct Broadcast IMAPP Real time product
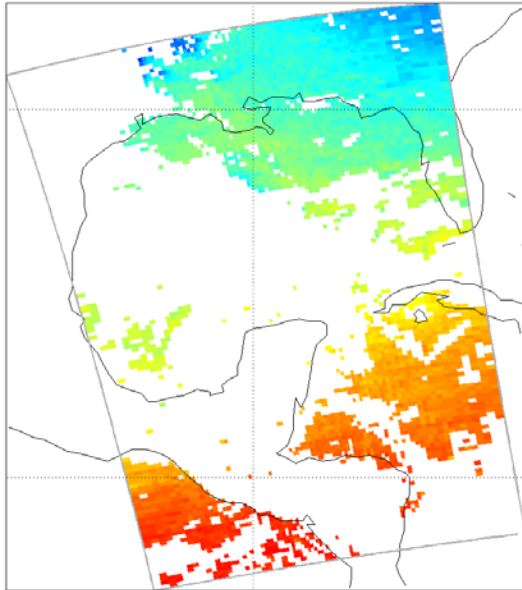
Aqua 8 September 2003

20:21 UTC

IMAPP AIRS RTV vs. ECMWF vs. Operational RTV: Temperature [K] at 500 mbar
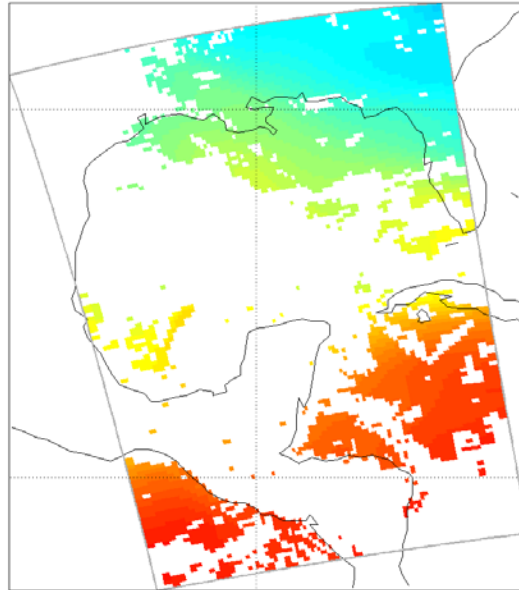
With Cloudmask

IMAPP AIRS RTV

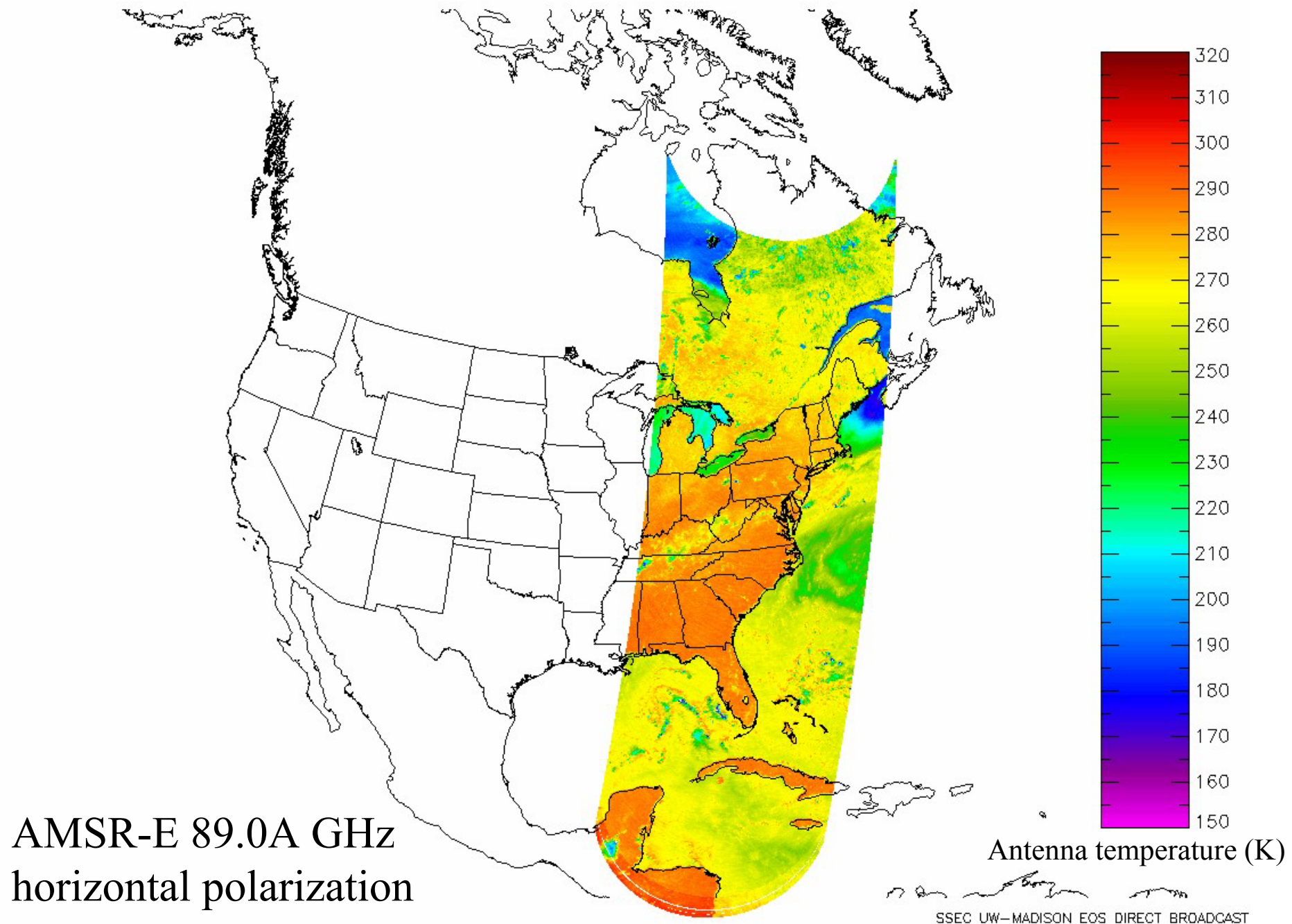ECMWF ANL

Interpolated to AIRS grid
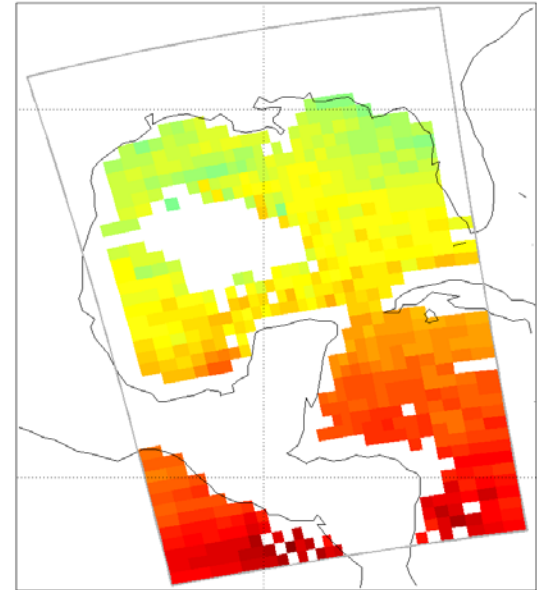
Operational AIRS RTV

• available on AMSU footprint (=3x3 AIRS FOVs) only

• missing areas → retrieval not successful or not validated yet

19
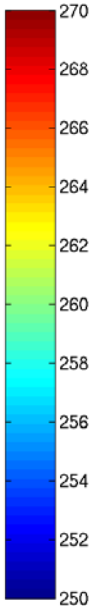
AMSR-E 2003/09/03 07:05:45.753 — 2003/09/03 07:17:47.199

AMSR-E 89.0A GHz
horizontal polarization

Antenna temperature (K)

SSEC UW—MADISON EOS DIRECT BROADCAST

Global Applications

Global MODIS IMAPP Community

Applications – *based upon sample of responses to IMAPP survey*:

- Hartbeeshoek, South Africa - CSIR Satellite Application Centre - MODIS Level 1B used for generation of surface reflectance, NDVI , BRDF, LST, SST

- Plymouth, United Kingdom - Plymouth Marine Laboratory - MODIS Level 1 and Level 2 cloud product, cloud mask, and atmospheric profiles products used as a deliverable for the EC funded CLOUDMAP2 project which finished in January 2004

- Taiwan, ROC - Center for Space and Remote Sensing Research, National Central University - MODIS Level 1 and Level 2 products used for studying atmospheric temperature, ozonosphere, sea surface temperature, chlorophyl, ocean color, vegetation indices and forest fires

Cloud Top Temperature Plymouth Marine Lab, UK

10 October 2003   11:57 UTC
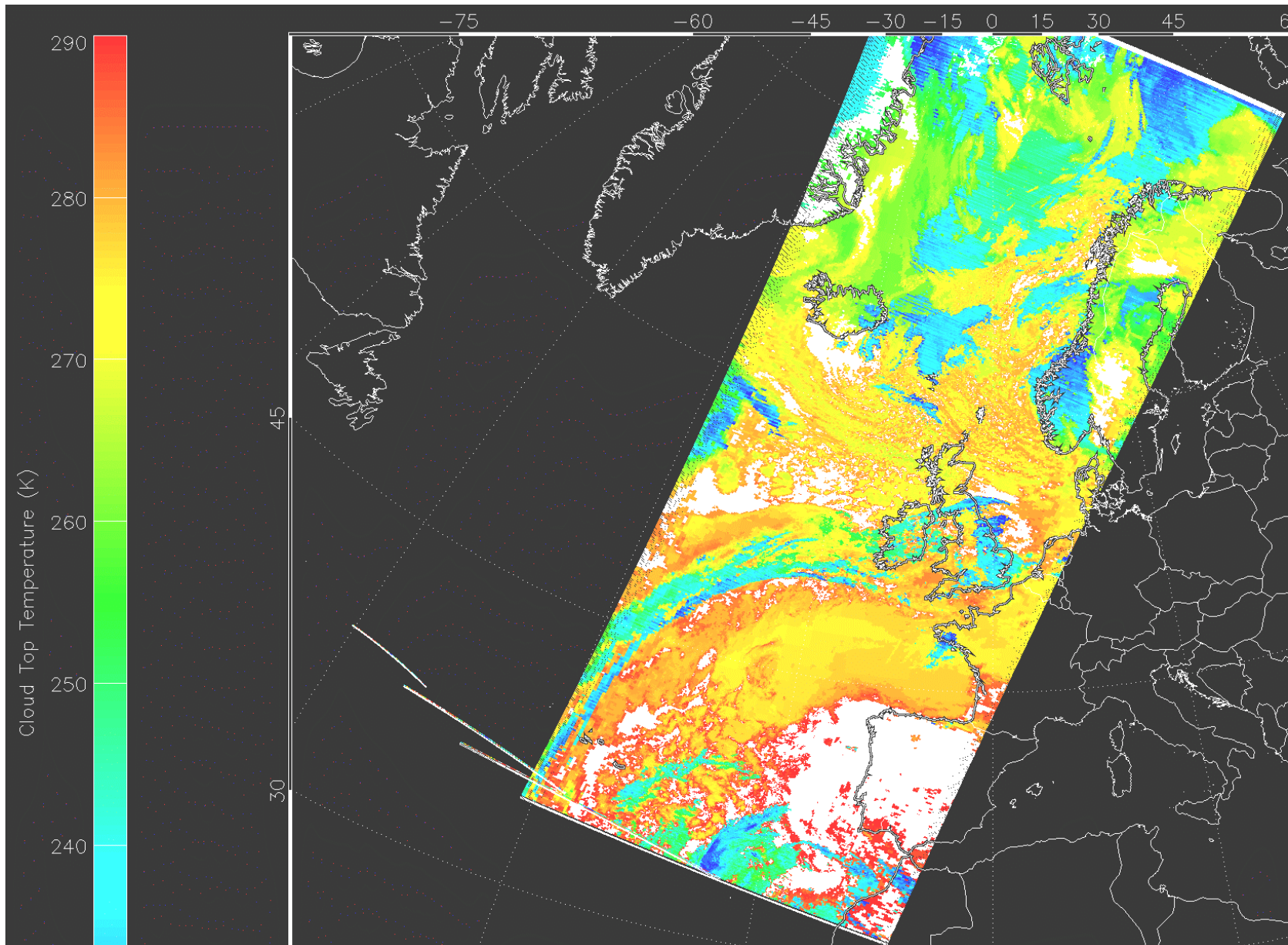
Global MODIS IMAPP Applications Continued

- **Sao Paolo, Brazil** - National Institute for Space Research – INPE - MODIS Level 1B used to serve INPE/CPTEC, IBAMA and other Governmental institutions

- **Missoula, Montana** - US Forest Service - MODIS Level 1B and eventually aerosol product used for fire monitoring

- **Alice Springs, Canberra and Hobart, Australia** - Australian Centre for Remote Sensing - IMAPP MODIS Level 1 and, in test right now, Level 2 cloud mask and cloud properties. These products are being utilized in various environmental applications

MODIS Product Page, INPE, Sao Paolo, Brazil

Global MODIS IMAPP Applications Continued

- **Chinese Academy of Science** -Institute of Geography and Resources Research, MODIS Level 1 and Level 2 products used for a variety of applications

- **Tromso, Norway** - Kongsburg Satellite Services - MODIS Level 1 and Level 2 products distributed with ground stations world wide for a variety of environmental applications

- **Moscow, Russia** - ScanEx Research and Development Center - MODIS Level 1, and Level 2 cloud mask and SST used for a wide range of land and sea surface monitoring tasks

- **Sioux Falls, South Dakota, USA** - EROS Data Center - MODIS Level 1 products are reprojected for users on the AmericaView project, a national and state partnership to enable remote sensing education, training, and applications

IMAPP MODIS Product Page, Moscow, Russia
Use IMAPP MODIS cloudmask as a means of choosing scenes for users

Global MODIS IMAPP Community

continued:

- Many, many MODIS applications in China

    Wenjian ZHANG presented many of these at last International EOS DB meeting – 17-20 November 2003

    - Cloud and aerosol applications

    - Disaster monitoring (Floods and Fires)

    - Snow and ice monitoring

    - Others

How Many IMAPP users are there?

- Not sure, software is free without registrastion – but know that it is used on every continent – including Antarctica.

MODIS view of Shanghai

The 3 channel composition image of ch1/ch4/ch3.. The blue arrow points Shanghai city district.

Other known IMAPP applications:

- Providing USA Weather Service forecasters with near real-time high spatial resolution imagery and products (NASA SPORT).

- Water quality monitoring - University of Wisconsin

- Aiding the Canadian Ice Service in monitoring the amount of ice on Hudson Bay for shipping concerns.

- Providing MODIS Aerosol and Cloud data for Infusing Satellite Data into Environmental Applications (IDEA) project to aid in Air Quality Forecasts by the US EPA.

Other known users:
- Naval Research Laboratory, Monterey, California, USA
- Satellite Services Division, NOAA/NESDIS, USA
- Atmospheric and Environmental Research, Inc, Lexington Massachusetts, USA
- Upper Midwest Aerospace Consortium, University of North Dakota, USA
- National Center for Environmental Prediction (NCEP), NOAA, USA
- MODIS Snow and Sea Ice Global Mapping Project, NASA/GSFC, USA

http://wwwghcc.msfc.nasa.gov/sport/sport_featured.html

http://wwwghcc.msfc.nasa.gov/sport/sport_featured.html

The IDEA team values your feedback! Please send any comments, problems and suggestions to SSEC Webmaster.

AIRNOW · MODIS · WFABBA

Latest Forecast Discussion - May 27, 2004

MODIS AOD over continental US shows relatively low aerosol loading with moderate AOD plume exiting the mid-Atlantic Coast. Region of moderate PM2.5 AQI in Midwestern AIRNow data is obscured by clouds.

Moderate (~0.4) MODIS AOD in south-central US forecasted to be advected towards Virginia and Carolinias on 05/28 with rapid advection off the South-eastern coast by 05/29. Possibility of recirculation of aerosol loading off the coast associated with high pressure system over Florida.

More
bradp 05:17 PM EDT | Comments (0)

http://idea.ssec.wisc.edu

Forecast Trajectories for MODIS Aerosol Optical Depth, Cloud Optical Thickness and 48 hour Air Parcel

MODIS 2004/05/27 AOD/COT & AOD Trajectories on 2004/05/28 16Z
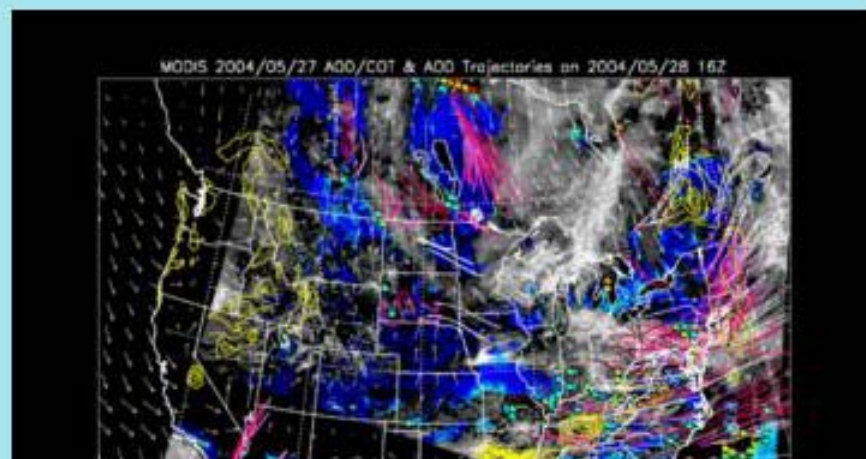
Regional Summary Plots of MODIS Aerosol Optical Depth and Cloud Optical Thickness

MODIS Aerosol Optical Depth   2004 05 28   EPA Region 1-3
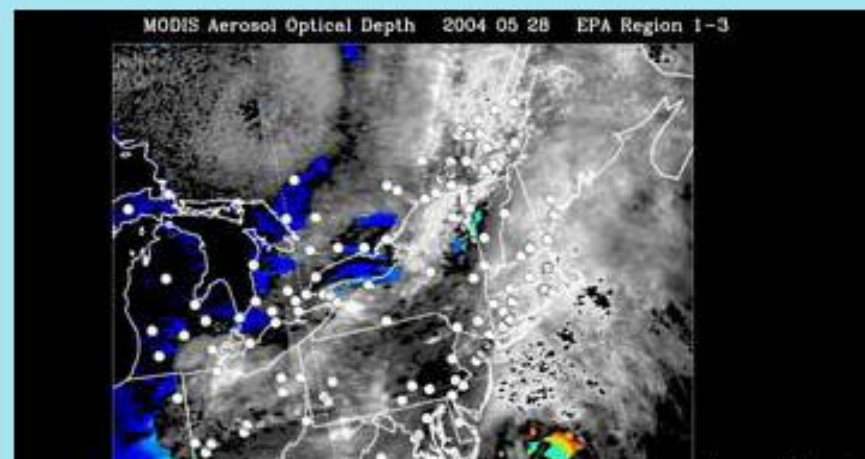
IDEA Trajectory Forecast   26 May 2004   21 UTC

MODIS 2004/05/25 AOD/COT & AOD Trajectories on 2004/05/26 21Z

| 0.0 | 0.2 | 0.4 | 0.6 | 0.8 | 1.0 | 1000 | 800 | 600 | 400 | 200 | 0 | 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 |

MODIS AOD   Trajectory Pressure (mb)   MODIS COT
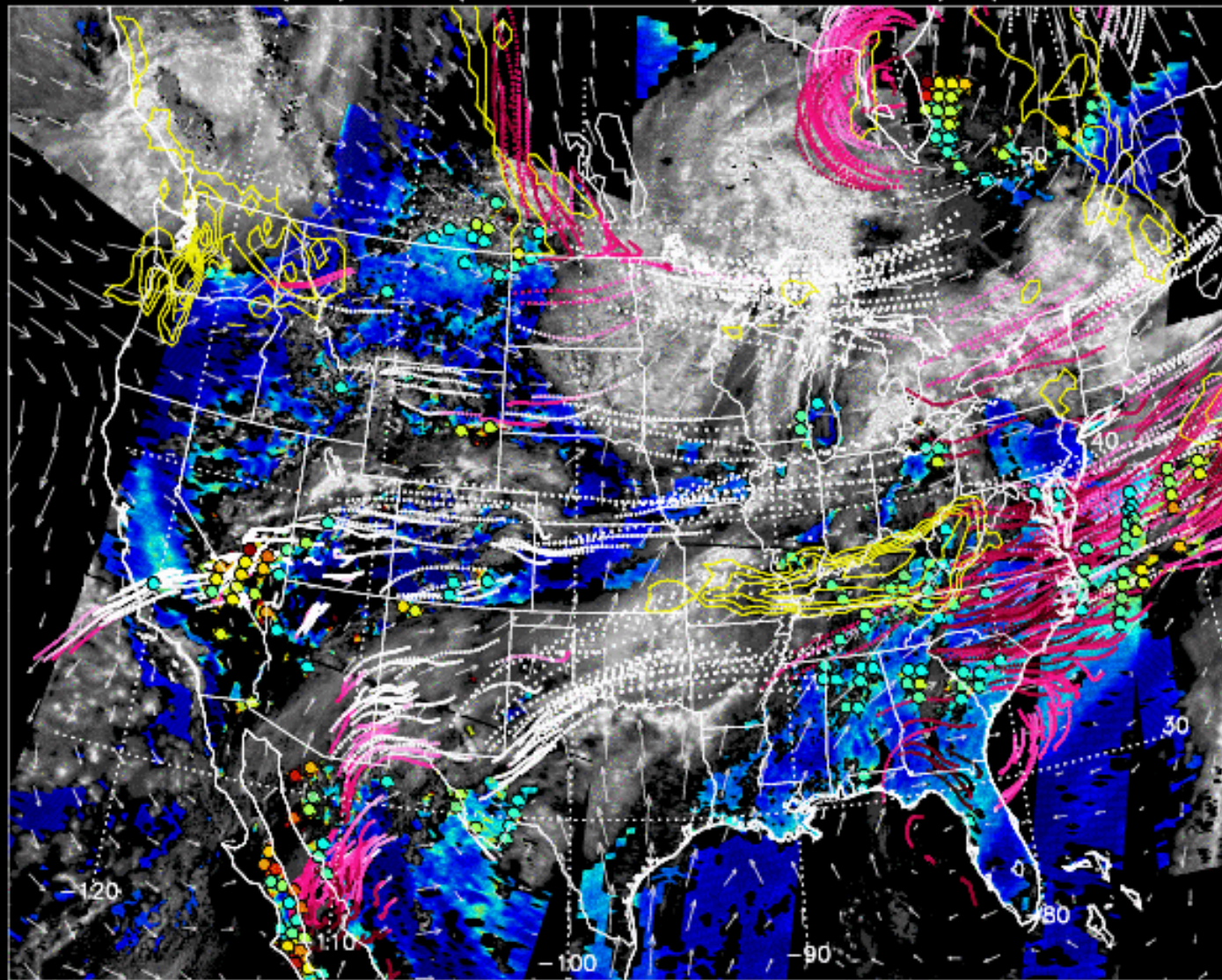
Water quality in Green Bay: summer 2001

Enhanced true-color MODIS images: bands 1 (red), 4 (green), and 3 (blue)

40 km

03 Jul · 08 Jul · 13 Jul · 03 Aug · 07 Aug · 14 Aug · 26 Aug · 28 Aug · 05 Sep · 30 Sep · 01 Oct

Chlorophyll *a* concentration, derived from MODIS data:

(mg/m³)
0 · 12 · 25 · 38 · 50+

03 Jul · 08 Jul · 13 Jul · 03 Aug · 07 Aug · 14 Aug · 26 Aug · 28 Aug · 05 Sep · 30 Sep · 01 Oct

Total suspended solids, derived from MODIS data:

(mg/L)
0 · 6 · 12 · 18 · 25+

03 Jul · 08 Jul · 13 Jul · 03 Aug · 07 Aug · 14 Aug · 26 Aug · 28 Aug · 05 Sep · 30 Sep · 01 Oct

Water clarity (Secchi disk transparency), derived from MODIS data:

(m)
<0.25 · 1 · 2 · 3 · 4+

03 Jul · 08 Jul · 13 Jul · 03 Aug · 07 Aug · 14 Aug · 26 Aug · 28 Aug · 05 Sep · 30 Sep · 01 Oct

Future IMAPP applications

AIRS Sounding System Software:

- L2 retrieval products – *First release in November*
  - T/q retrievals, Total Precipitable Water Vapor
  - Single pixel and 3x3 fov
- Cloud Detection
- Cloud Properties (Height, Emissivity)
- Cloud Liquid Water
- AMSU Precipitation
- Combined MODIS/AIRS products

MODIS L2 products:

- Aerosol Optical Depth – *First release in September*
- Surface Reflectance
- Suspended Sediment Concentration
- Cloud Optical Properties
- Scene Classification
- Snow Cover/Lake Ice
- Ocean Color

Future IMAPP applications (Continued)
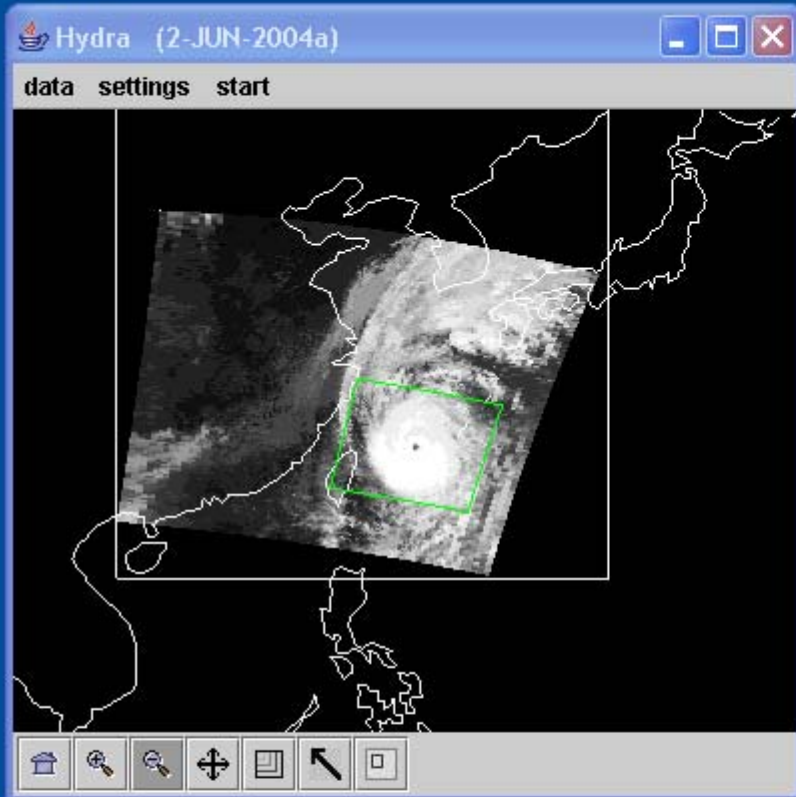
AMSR-E:

- Soil Moisture
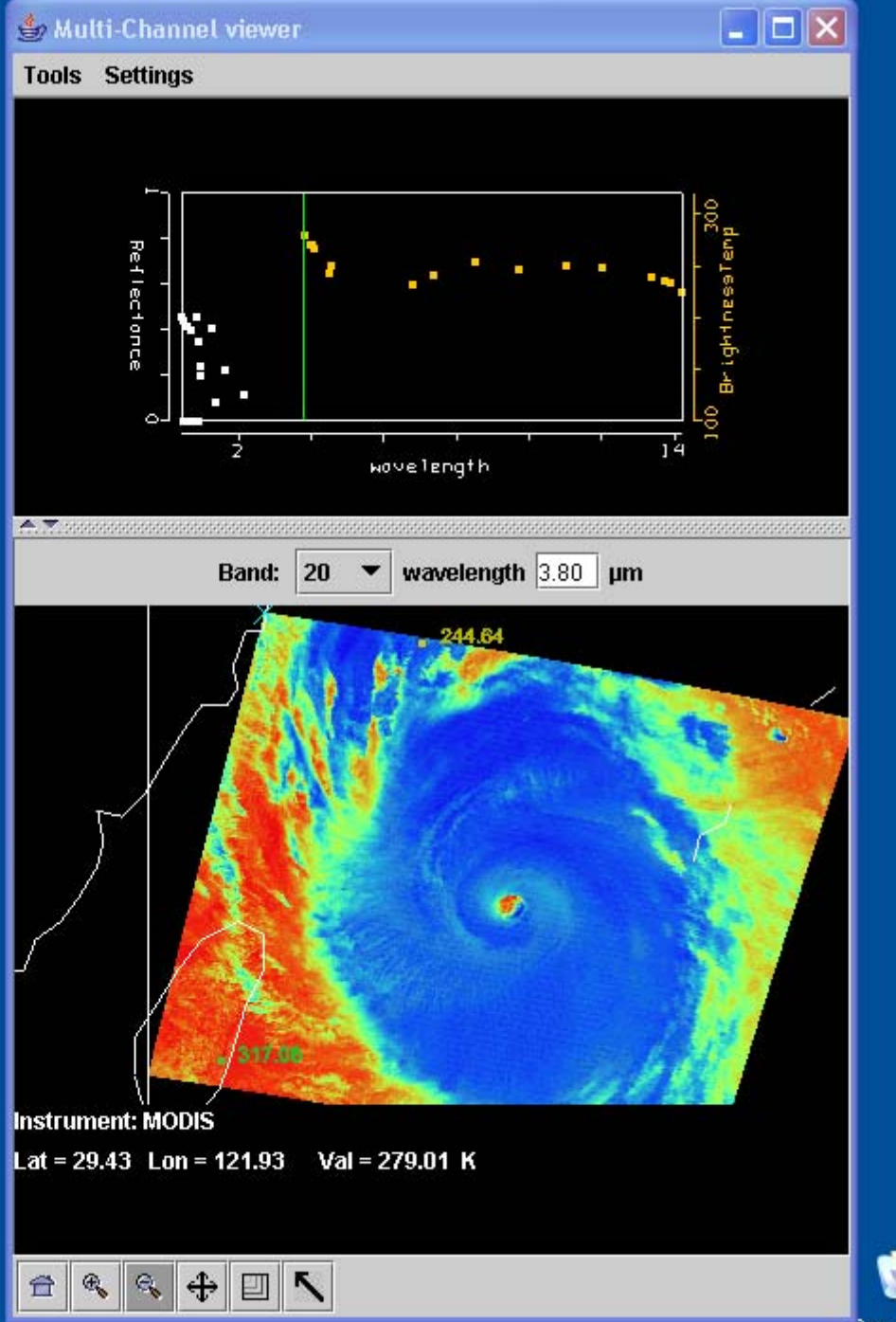- Precipitation

Utilities:

- Utility to visualize L1B and L2 IMAPP products
  - hydra
  - Utilities to share data with other users
    - DODS server
    - ADDE server
- Utilities to collocate MODIS/AIRS pixels
- Corrected reflectance tutorial
- Guide to converting IMAPP L1B format
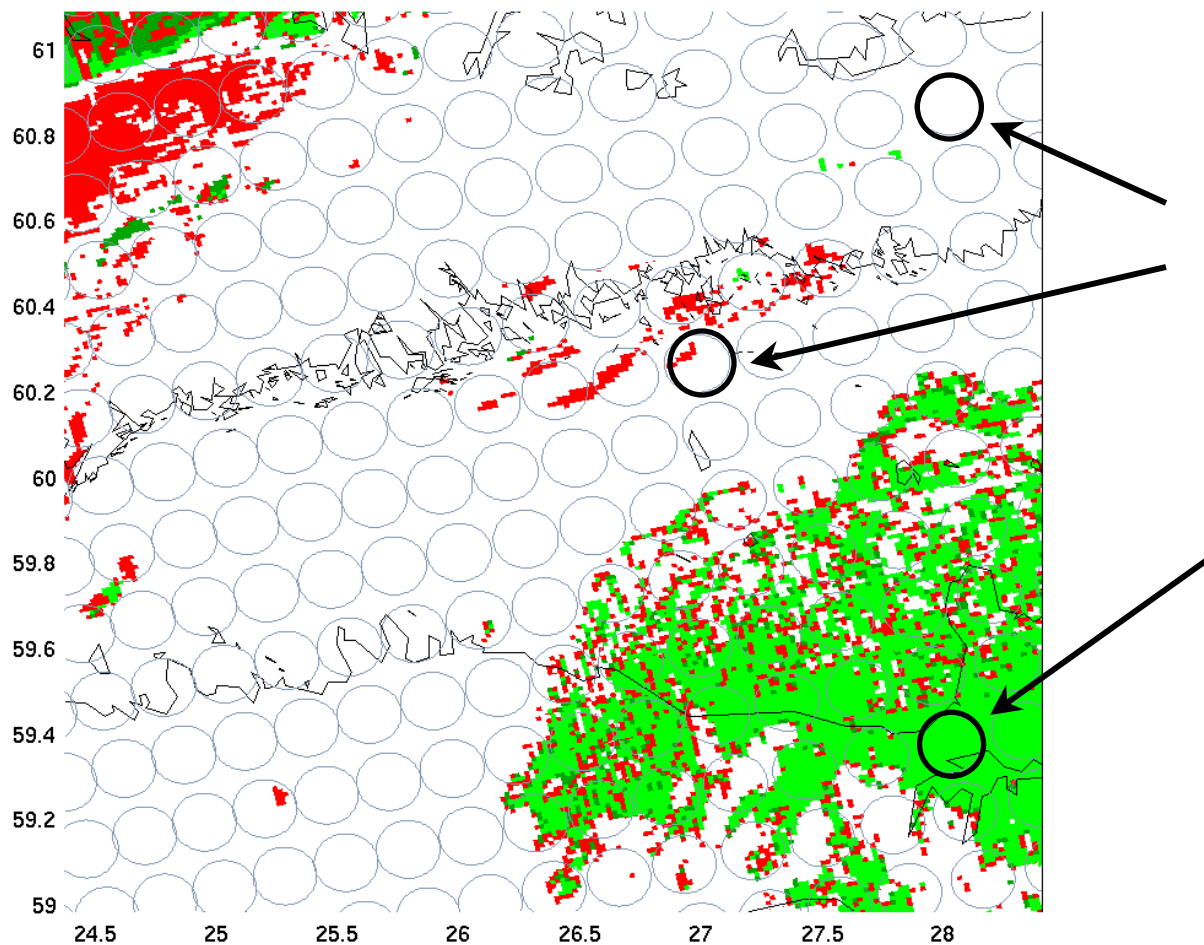 to DAAC format

Workshops:

- More IMAPP remote sensing workshops planned

Hydra Visualization Tool

AIRS Clear Flag from MODIS cloud mask

Not Determined	Cloudy	Uncertain	Probably Clear	Confident Clear

Summary

• IMAPP is providing the international community with the means to process Terra MODIS and Aqua MODIS and AIRS data independently. Level 2 MODIS products are being used for a variety of applications internationally.

• MODIS, AIRS L1B and a subset of MODIS L2 algorithms are available today.

• Additional MODIS and AIRS L2 products are under development, including MODIS surface reflectance product and AIRS/MODIS collocted combined products

• AMSR-E L1B software package will be released soon.

• We intend to follow on from Terra and Aqua to NPP and NPOESS.

IMAPP AMSR-E Processing

Goal:

Release freely available package for processing AMSR-E from Level 0 to Level 1B initially, followed by Level 2 in future.

Status:

• RSS has delivered AMSR-E L1B package to SSEC in source form
• Output format is flat binary, arbitrary overpass size
• SSEC has been running beta version in near real-time
• SSEC has been developing these Level 2 products for testing in DB:
    - Soil moisture
    - Precipitation

Schedule:

L1B released by the end of the year.
Level 2 products in the beginning of 2005.